b-tag HLT status and plans code in 160, trigger validation

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Implementation and performance of b-lifeltime and b→μ for HLT-exercise and in 1.6.0

b-Lifetime Tagged HLT: Level-1

- Trigger thresholds for L = 10^{32} cm^{-2} s^{-1}
- Level 1:

Et (1st jet)	>	150 GeV
Et (2nd jet)	>	100 GeV
Et (3rd jet)	>	50 GeV
Et (4th jet)	>	30 GeV
or HTT	>	300 GeV

- L1 is 96% efficient for hadronic t-tbar.
  - N.B. Using only Et (4th jet) or HTT is almost as good
- 0.014% efficient for minibias (= 1.1 kHz)

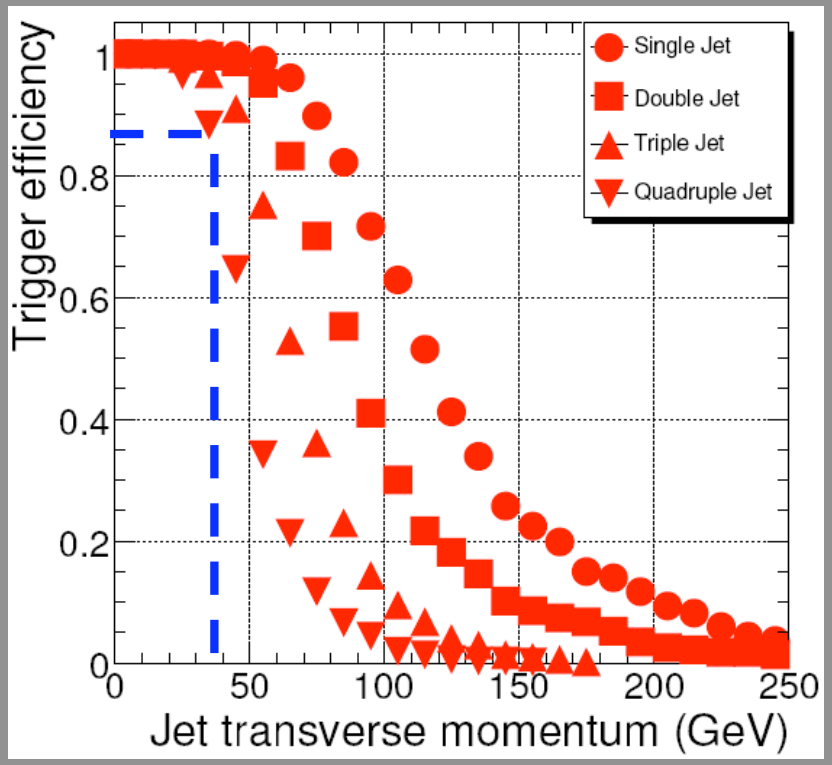
b-Lifetime HLT: Level 2

Et(1st jet) > 180 GeV; Et(2nd jet) > 120 GeV

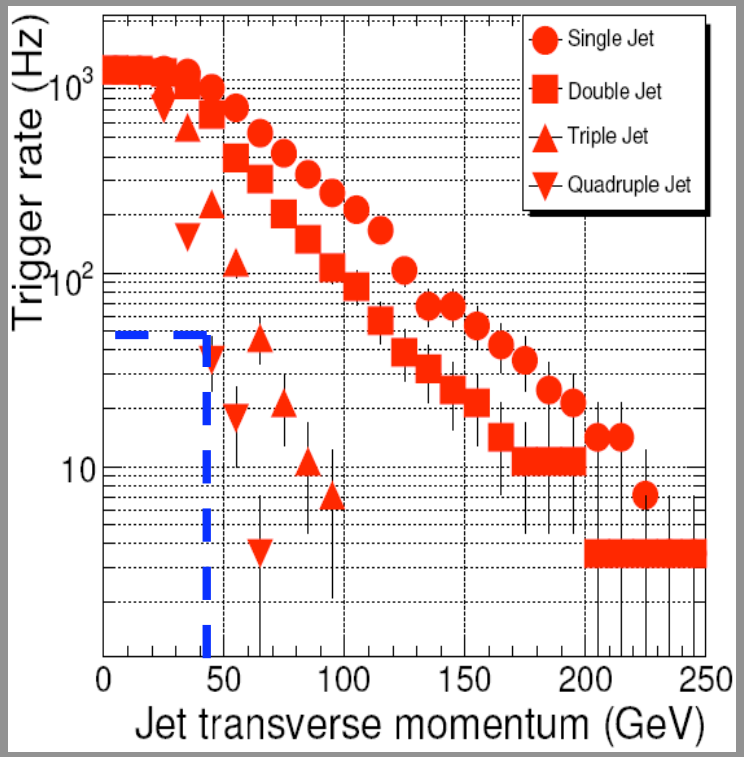
Et(3rd jet) > 70 GeV; Et(4th jet) > 40 GeV

or HTT > 470 GeV

t-t efficiency relative to Level 1



Minibias rate

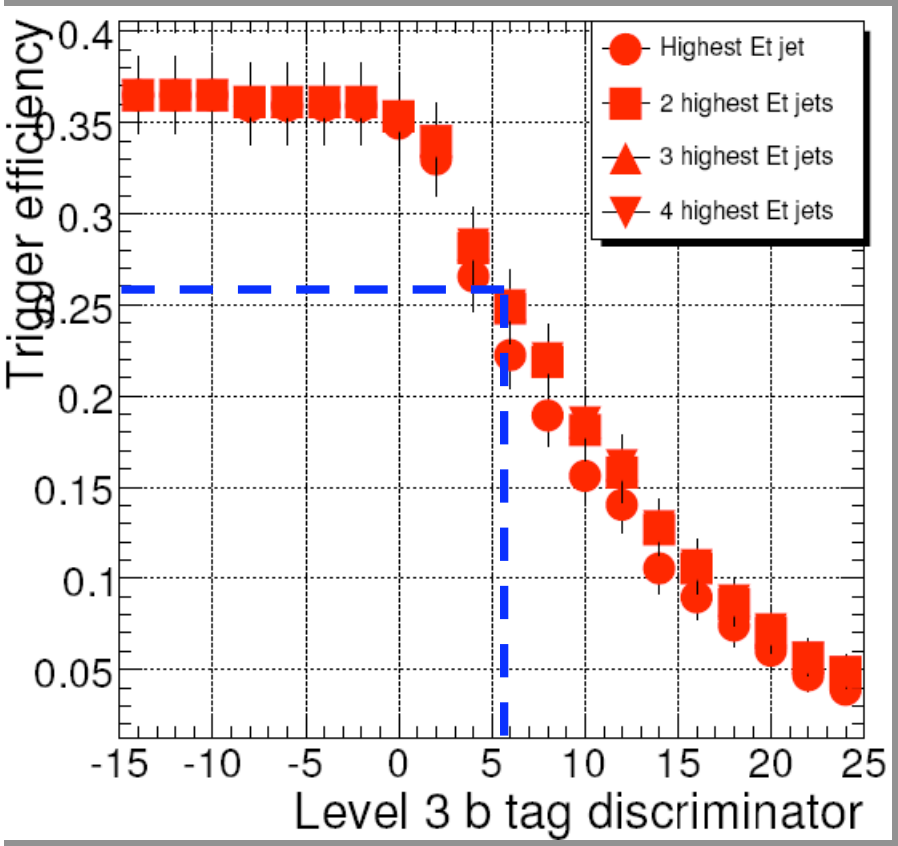


b-Lifetime HLT: Level 2.5 and 3

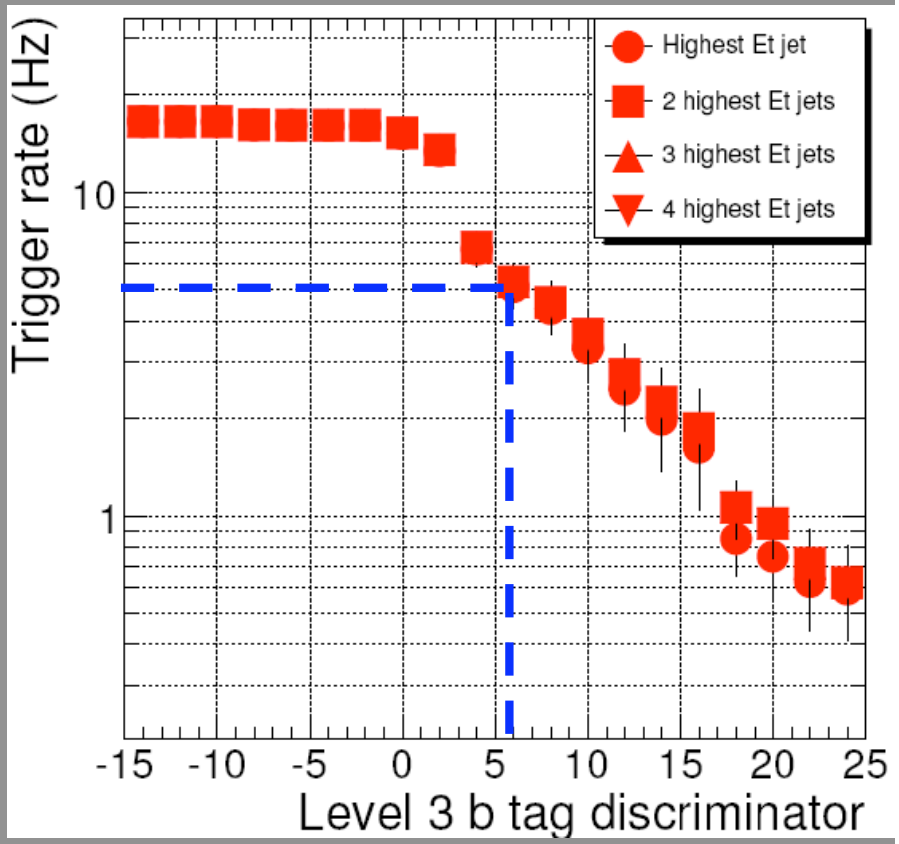
- Level 2
  - Make P.V. from pixel `triplet' tracks.
  - Select 4 highest Et jets with Et > 35 GeV.
  - Run `track-counting' b-tag on selected jets, using pixel `triplet' tracks
  - Require ≥ 1 tagged jet (≥ 2 tracks with 3-D d0 > 3.5s).
- Level 3
  - Reuse P.V. from pixel `triplet' tracks.
  - Consider only jets tagged as b-jets at Level 2.5
  - Reconstruct tracks in (h,f) window around jet.
    - Stop track recontruction when 8 hits assigned to track.
  - Run `track-counting' b-tag on selected jets, using these tracks.
  - Require ≥ 1 tagged jet (≥ 2 tracks with 3-D d0 > 6s).

b-Lifetime Tagged HLT Level 3

t-t efficiency relative to Level 1



Minibias rate



b → μ HLT: Level 1 Triggers

- Rates and Eficiencies:
  - Muon+jet Trigger
  - A_MU5_Jet15:
    - At least one muon p_T>5 GeV and one jet E_T>15 GeV
  - Rates at 10^{32} cm^{-2} s^{-1} : 1.6 kHz
  - Efficiencies for ttbar (all hadronic/mu events): 0.74

  - Jets Only:
  - HTT250:
    - Sum of jet p_T > 250 GeV
  - Rates at 10^{32} cm^{-2} s^{-1} : 2.56 kHz
  - Efficiencies for ttbar (all hadronic/mu events): 0.95

b → μ HLT options

- Level 2:
  - Various num of jets and ET thresholds available
  - Those relevant for ttbar (all-hadronic/mu):
    - Three jet with pT > 70 GeV/c.
    - Four jets with pT > 40 GeV/c.
    - Event hadronic activity HT > 370 GeV.
- Level 2.5:
  - Level 2 muons (Muon-chamber μ) required to be near one of the Level 2 jets, $\Delta R(\mu - \text{jet}) < 0.4$
    - using the Soft Lepton b-tagging package.
- Level 3:
  - Use L3muons (μ confirmed by Tracker)
  - $\Delta R(\mu - \text{jet}) < 0.4$.
  - Require μ pT (rel) > 0.7 GeV/c w.r.t. the jet axis.

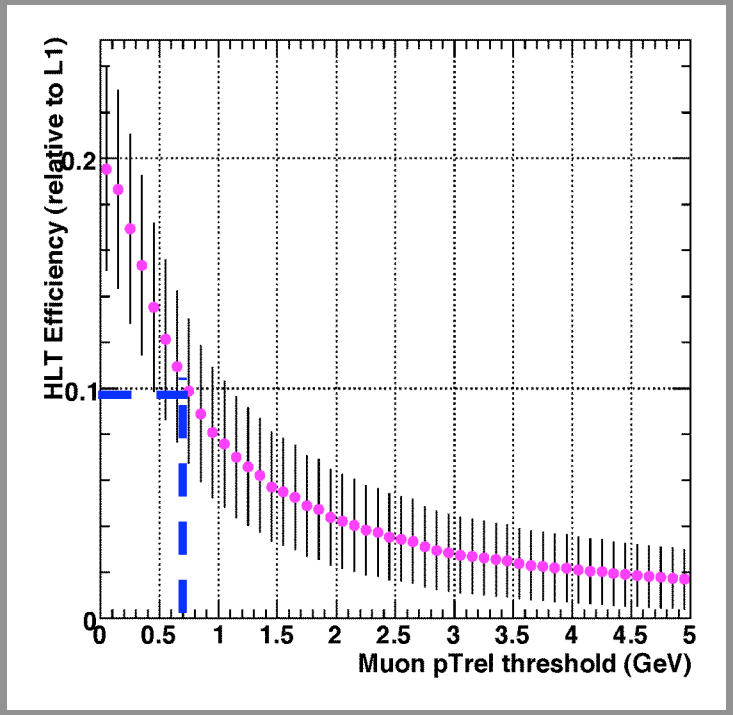
b → μ tag in HLT

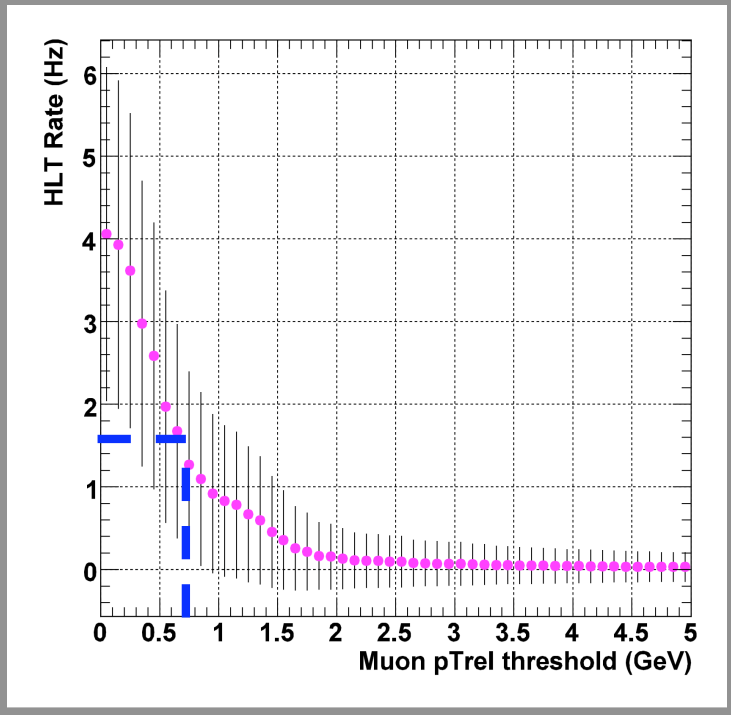
L1 : A_HTT250

- pTrel of muon wrt jet
- ttbar efficiency

with generated μ
relative to Level 1,

QCD Rate

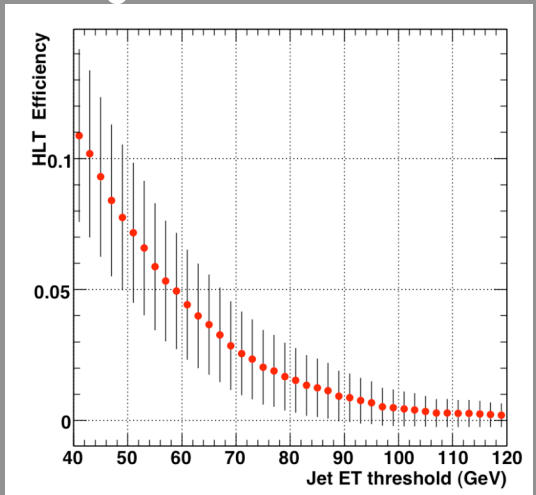


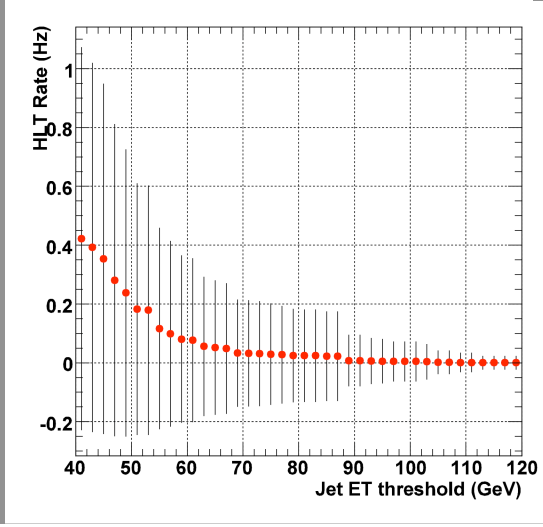


b → μ tag in HLT

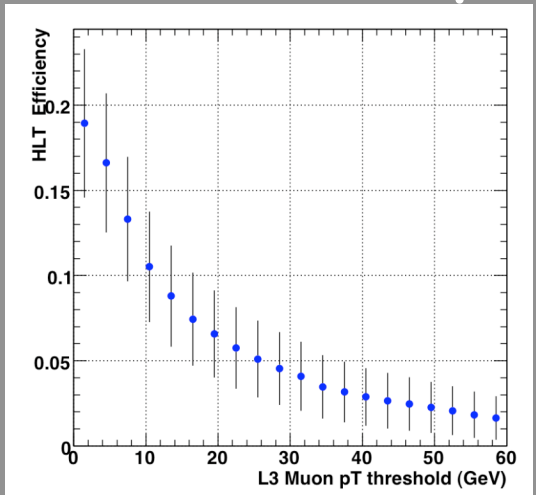
L1 : A_HTT250

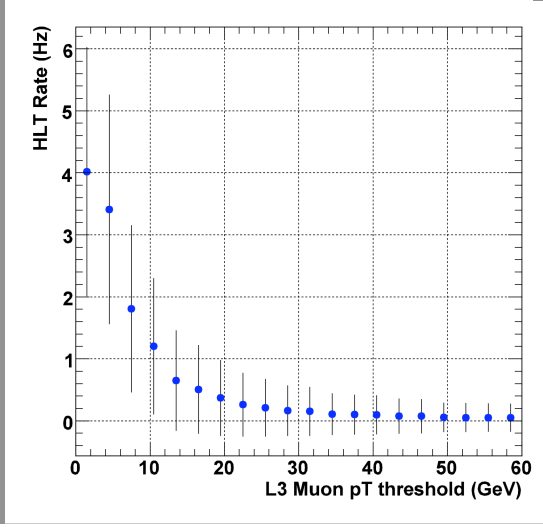
- Additional knobs to control rates
- pT of 4th jet in L2
- ttbar
- QCD





L3 muon pT





b→μ HLT trigger for b-jet performance control samples

- b → μ HLT provides jet + μ data for b tag performance measure
  - Trigger requires μ in jet with Et > 20 GeV
    - prescaled by factor 20
    - has rate of 4 Hz = 40M events/year.
    - Rate dominated by low Et jets
- For later version of optimized HLT table, define a sequence of triggers with higher jet ET threshold, so could use smaller prescale with higher threshold in later versions of optimized HLT table.
  - used to measure b tag performance with data

b-HLT Code Infrastructure

Code Status & How to run it !

- Trigger available in CMSSW 1.3.1.HLT5
- And non-validated version in 1.6.0.pre4.
  - HLT in CMSSW 1.3.1.HLT5
    - runs on 1.2 or 1.3 data.
  - HLT in CMSSW 1.6.0
    - runs on 1.4, 1.5 or 1.6 data.
- For b-lifetime HLT:
  - Run HLTrigger/btau/BJetTrigger.cfg
- For b$\rightarrow\mu$ HLT
  - HLTrigger/btau/BSoftMuonTrigger.cfog
- For all HLT:

  HLTrigger/Configuration/test/HLTTable.cfg

Software Design

- HLTrigger/btau/interface/HLTJetTag.h
  - Inherits from HLTFilter
  - Implements function "bool filter()", which says if event accepted.
    - It does so by accessing b-tagged jets from Event, & requiring that there be more than N (=1) of them etc.
- Stores in Event, an HLTFilterObjectWithRefs, which contains references to the b jets which caused the event to trigger.

Infrastructure

- Structure of b tagging algorithms (2 Stages)
  - compute the tagging variables for each algorithm (lifetime, soft lepton, ...)
  - combine (a subset of) them into a discriminator
    - more discriminators can be computed from the same set of tagging variables.
      - faster than recomputing everything
- Input objects
  - all algorithms should be able to handle all jet types inheriting from **reco::Jet**
    - interface still needs to be tweaked (using View<Jet>)

Status as of 1.6.0(-pre4)

- code and configuration files have been updated
  - works within the HLT Global Table
    - using pre3 + tags for IP tagger
    - Pre4+tags for b→μ tagger
- run over 1000 QCD 380-470 GeV events, from 1.5.1 RelVal sample
    - 134 passed the **HLTB[1-4]Jet**, **HLTBHT** path
    - 21 passed the **HLTB[2-4]JetMu** paths
    - 2 passed the **HLTB1JetMu** (prescaled by a factor 20)
    - 24 passed the **HLTBHTMu** path
  - algorithmic part works
  - Still need to validate the results

Updates since 1.3.1-HLT6

- For IP tagger:
  - uses updated regional seeding and tracking (following the work done by Tau)
    - will be moved to a common place
- For tagger
  - can run with no primary vertex
    - When set to 'none' assumes the beam spot position and errors
    - won't compute the lepton's IP will
  - runs with no tracks
  - can tag either a CaloJet or a JTA
    - Plus other cleanups

Plans/Todo List

- migrate IP tagger to updated 1.5.x TrackIP b-tagger
  - can compute both tracks IP and jet probability
- For both taggers:
  - improve offline package to use View<Jet> to allow all Jet types;
  - Rename all modules and sequences
- Validation
  - In the works. Have first pass code, but not committed or part of the validation suite.
  - Intend to produce threshold curves (the ones we put in the note) and tables of efficiencies.
  - We could run on L1 skimmed minibias, QCD in one pthat bin and ttbar.
  - The validation suite should run automatically on all new releases, just like it should for Offline Software validation. It should automatically report discrepancies with the previous release.

Plans/Todo List

- Q: Should the triggers inherit all off-line improvements/changes automatically?
  A: YES

- Q: How can we ensure that HLT can choose between adopting or rejecting changes when running on-line?
  - A: Run validation code with all new releases. This exercise will be the first indicator if improvements should be incorporated or rejected.

Performance of b-jet triggers

- Strategy to measure b-jet performance using the data
  - Same for both b-jet (lifetime or b → μ) HLT tag type
- Use a set of complementary HLT paths
- Measure performance in two diff ways
  - Generic HLT b-jet tag type performance
  - HLT b-jet performance with respect to an "offline b-jet" tag type.
- Provide b-jet HLT efficiency as a function of:
  - Jet PT
  - b-tag discriminator (lifetime) or μ– pTrel (b → μ)

HLT b-jet performance

- For b-lifetime trigger:
  - Use the set e+jet HLT and e+b-jet HLT
  - Some basic differences between these will need to be put on an equal footing at the analysis stage
    - the e and b-jet pT requirement in e+b-jet HLT is lower (10, 35 GeV) than those (12,40) in e+jet
    - Level 1 jet pT (20 vs 30 GeV)

$e + b$-jet	A_IsoEG10_Jet20	(10, 35)	0.1 ± 0.0
$e +$ jet	A_IsoEG10_Jet30	(12, 40)	11.6 ± 1.2

HLT b-jet performance

- For b → μ tag trigger:
  - Use the set mu+jet HLT and mu+b-jet HLT
  - Some basic differences
    - Can equate at analysis level
    - the b-mu-jet pT requirement in mu+b-jet HLT is lower (20 GeV) than that (40) in e+jet
  - Compare the two sets to get the b-mu trigger performance

$\mu + b$-jet	A_Mu5_Jet15	(7, 35)	0.1 ± 0.0
$\mu + b \rightarrow \mu$-jet	A_Mu5_Jet15	(7, 20)	0.1 ± 0.1
μ + jet	A_Mu5_Jet15	(7, 40)	6.3 ± 0.7

    - The b-jet pT is 35 GeV
    - Can use mu+jet vs mu+b-jet for b-lifetime tag as well.

Measuring performance…

- Then on the given set of trigger (ejet, e+b-jet) or (mujet, mu+b-mu-jet)
  1. run an offline b-jet tagger
  - then compare the offline tagged b-jet and see if the lifetime tagger has also selected this jet and extract the HLT b-lifetime tag efficiency
  2. Run the offline soft-lepton-tagger
  - then compare the offline agged b-mu-jet and see if the HLT b-mu tagger has also selevted this jet in order to measure the HLT b-mu-tag efficiency

- Can also do this on offline selected top quark samples.

Conclusion

- b/lifetime and b/μ-jet triggers at HLT have been defined and are available for use.
- Code updates in 1.6.0(-pre4) are implemeted.
- Validation suite needs to be improved and made part of the official suite
- Plans for measuring the b-jet performance from data and b-jet trigger turn on curves as a function of b-jet variables are being developed.